SPOLIA RUNIANA.—II. *Funiculina quadrangularis* (Pallas); *Diazona violacea*, Sav.; *Forbesella tessellata* (Forbes); variation in *Ascidia*; and records of various rare Invertebrata. By W. A. HERDMAN, F.R.S., F.L.S., Professor of Zoology in the University of Liverpool.

(PLATE 19.)

[Read 6th November, 1913.]

IN Part I. of "Spolia Runiana," last year *, I dealt mainly with Hebridean specimens of the giant Pennatulid, *Funiculina quadrangularis*, and of the Compound Ascidian *Diazona violacea*. During the cruise of the yacht 'Runa' in the present summer (July and August 1913), we were fortunate enough to capture many additional specimens of both these comparatively rare animals, and this wealth of material has enabled me to add some further particulars to what was previously recorded. During the cruise I paid particular attention to the Tunicata, and preserved large numbers of several common species with a view to studying individual variations and their bearing on specific characteristics. We obtained also some specimens of the less common Cynthiid *Forbesella tessellata* (Forb.), and the examination of these has enabled me to offer some remarks upon the position of this isolated species in the "system" of classification.

The occurrence of a few other rare forms seems worth putting on record :—

I. NEW OR INTERESTING RECORDS.

(1) The Starfish *Pteraster militaris* (O. F. Müll.) was dredged in the Inner Sound, between the Island of Raasay and the mouth of the Gair Loch (Ross-shire), from a depth of 20 fathoms, on August 18th. This is a northern species, found on the coast of Norway, and not previously known, I believe, from the British seas — the nearest locality being the Faröe Channel, 'Porcupine' expedition, from over 400 fathoms; and, again, the 'Triton' expedition, 530 fathoms.

Prof. Jeffrey Bell in a letter (Oct. 22nd) remarks : "I do not suppose it occurs in strictly British waters." Consequently the present record makes an addition to the known British Fauna.

Our Scottish specimen measures as follows :—

R = 22 mm. r = 8 mm.
Greatest height = 8 mm.
Breadth of arm at base = 10 mm.

A red eye-spot is conspicuous at the extremity of each arm.

* Journ. Linn. Soc., Zool. vol. xxxii. p. 163, May 1913.

(2) The Echinid *Echinus acutus*, Lamk., was dredged in the Sound of Mull, north of the Green Islands, from a depth of 20–30 fathoms on July 16th, 1913.

This is a southern form which occurs in the Atlantic to the west and south of Ireland, and has apparently not been recorded previously from Hebridean waters.

The dimensions of our specimen are :—

Diameter of test = 54 mm.
Height = 36·5 mm.
Diameter of peristome = 17·5 mm.
Diameter of periproct = 6·5 mm.
Largest spine = 26 mm.

The bases of the spines are of a greenish colour. The conspicuous characters of this Echinid when alive—which at once attracted my attention to it in the dredge—were the comparatively few but very long spines, and the general white coloration.

(3) Amongst other more noteworthy Echinoderms obtained were :—

Antedon tenella (Retzius), as well as *A. phalangium* (G. Müll.) and *A. bifida* (Penn.).
Asterias muelleri (Sars), as well as *A. rubens*.
Ophiocnida brachiata (Mont.), with other commoner Ophiuroids.
Phyllophorus pellucidus (Düb. & Kor.).

Mr. H. C. Chadwick, who has examined these Echinodermata for me, throws doubt upon the distinctness of the last species from *P. drummondi* ; and he is inclined not to recognise the validity of the characters drawn from the spicules known as "tables" in the integument of *P. pellucidus* and of *P. drummondi*.

(4) Several boulders brought up (with much labour, and risk to the dredging-gear) from some of our deeper hauls, on rough bottoms, yielded a few examples of the rare solitary corals :—

(?) *Paracyathus taxilianus*, Gosse ; the Minch, 30 fathoms—a doubtful species.
Caryophyllia smithii, Stokes ; off Ardnamurchan, 22 fathoms ; and south of the Island of Eigg, 30 fathoms.

We also got the following other noteworthy Actinozoa :—

Epizoanthus incrustans (Düb. & Kor.), off Vaternish Pt., Skye, 50 fathoms ; and *E. couchii* (Johnst.), Loch Hourn, 35 fathoms.

Sarcodictyon catenata, Forbes, at many localities, and of three quite distinct colours, viz. :—(1) the usual deep red, (2) pale yellow or creamy white, and (3) a bright cinnamon tint, exactly as figured by Forbes and Goodsir * in 1851 from the specimen dredged off the Croulin Islands, and which they

* Trans. Roy. Soc. Edin. vol. xx. p. 307.

described as a new species under the name *S. agglomerata*. We dredged some specimens of the last from the original locality, but I have no doubt they are simply a colour variety of *S. catenata*.

(5) Professor Dendy, who has kindly looked over the sponges of the 'Runa' collection, notes the following as the more interesting forms, all from the Shiant East Bank and neighbouring parts of the Minch :— *Tethya lyncurium*, *Ficulina ficus*, *Suberites carnosus*, *Dictyocylindrus stuposus*, *Phakellia ventilabrum*, *Ph.* (*Isodictya*) *infundibuliformis*, and a series of *Quasillina* (*Polymastia*) *brevis* and *Polymastia mammillaris*, which Prof. Dendy says "seems to indicate that Bowerbank was right in assigning the species, *Q. brevis*, to the genus *Polymastia*; but the question wants working out with specially preserved material."

Amongst the other, commoner, sponges obtained were many specimens of the large white *Esperella lingua*, and every specimen examined had embedded deeply in its interior some examples of the eggs or embryos of the cuttle-fish, *Rossia macrosoma*. I had found these in the same position under the same circumstances the previous summer, and, now again in 1913, I found sometimes quite young eggs and sometimes far advanced embryos, with the eyes and the arms and other parts of the cuttle-fish distinctly visible on removing the opaque egg-shell. This year, however, on opening some of these eggs, I found no cuttle-fish embryo, but the whole of the interior of what had evidently been the covering of the cuttle-fish egg filled up with sponge-tissue like that outside. The only explanation I can suggest is that some of the eggs or embryos die, or are unable to break out through the sponge to the exterior, and that in these cases the neighbouring tissue grows into the capsule and replaces the normal contents.

(6) Mr. A. O. Walker, who was with us on the 'Runa' for a few days in the earlier part of the cruise collecting Amphipods, and who has kindly examined all the higher Crustacea obtained, reports as follows :—"The total number of species of Malacostraca taken is 108, made up as follows :— Decapoda 23, Cumacea 2, Euphausiacea 2, Isopoda 5, Amphipoda 76.

"Of these, the following do not appear in Canon A. M. Norman's list of Crustacea collected in the Shetland Seas in 1861–7 (Report, British Association, 1868) :— *Nephrops norvegicus* (Linn.), *Philocheras sculptus* (Bell), *Eudorella emarginata* (Kr.), *Campylaspis glabra*, G. O. Sars, *Conilera cylindracea* (Mont.), *Lysianassa ceratina*, A. O. Walker, *Tryphosa Höringii*, Boeck, *Socarnes erythrophthalmus*, Robertson, *Hippomedon denticulatus* (Bate), *Metaphoxus fultoni* (Scott), *Neopleustes assimilis* (G. O. Sars), *Maera tenuimana* (Bate), *Gammarus duebeni*, Lillj., *Jassa pusilla* (G. O. Sars), and *Corophium bonellii*, M. Edw."

A specimen of *Munida bamffica*, dredged in the Minch, showed on one side the swollen carapace indicative of a Bopyrid parasite. Mr. T. R. R. Stebbing has kindly examined the specimen for me, and finds that the cavity contains

only the small male of a species of *Pseudione*. The *Munida*, we find, is also infested by a Rhizocephalan parasite, the *Triangulus munidæ* of Geoffrey Smith *—probably a new record for the British fauna.

(7) Miss L. R. Thornely, who has examined and identified the Polyzoa collected on the cruise, reports to me a list of 52 species, some of which are of considerable interest — one (*Mucronella abyssicola*) having been previously recorded from the Shetland Seas only. Our specimen was obtained from the Minch, off the west coast of Skye. *Lepralia polita* and *Idmonea atlantica* are also worthy of note.

(8) Knowing that Mr. E. Heron-Allen and Mr. A. Earland were engaged on a 'Monograph of the British Foraminifera,' it occurred to me when arranging the work of this cruise, that samples of our dredged deposits might possibly fill some gaps in their list of localities.

Mr. Heron-Allen supplied us with two dozen canvas bags which were duly filled with fair samples of the unwashed mud, sand, or other material as it was emptied from the dredge on to the deck.

These samples are now being examined, and Messrs. Heron-Allen and Earland report as follows in regard to them :—

"It has been a matter of great satisfaction to us that we have been entrusted with this series of samples. Apart from any intrinsic merit or interest which they possess in themselves, they greatly enrich, and fill gaps in, the collection of material already at our disposal from these seas, linking up as they do the 'Goldseeker' dredgings with the work of Messrs. Balkwill and Millett in the Galway District, our own in the Clare Island District, and that of Mr. G. Wright on the 'Helga' and other dredgings off the west and south-west of Ireland.

"So far, four bags of material have been examined, with results at once satisfactory and surprising. Indeed, whether the material is a shore-sand or a dredged mud, Miss Catherine Herdman, to whom we understand we owe the collection of the samples, seems to have displayed an unerring instinct for those muds and sands which were exceptionally rich in quantity of specimens and quality of species.

"In Sample No. 1 (At anchor, Lowlandman's Bay, Jura, 5 fms.), in addition to a series of 20 species of the genus *Lagena*, we have found the family of the Textularidæ very finely represented, the otherwise dominant form being a robust and highly papillate *Rotalia* of the *beccarii* type, attaining remarkable dimensions in enormous quantities. The Station yielded 89 species.

"Sample No. 2 (Dredging, Sound of Mull, 20 fms.), which reached us as a cake of hard black mud, 254 c.c. in bulk, became on the sieve 5 c.c. of fine material, which yielded 107 species. The dominant feature of the dredging

* This specimen has since been examined by Mr. Geoffrey Smith, who finds that this fresh material enables him to correct the description in his Naples Monograph and to show that these parasites of *Munida* should be included in the genus *Lernæodiscus*, the other members of which are also parasitic on the Galatheidæ.

was the presence of many hundreds of the rare species *Ammodiscus charoides*, Jones & Parker sp. Among the 39 species of Lagenidæ, were fine specimens of *Nodosaria filiformis*, d'Orbigny, *N. vertebralis*, Batsch sp., and *N. roemeriana*, Neugeborer, and *Sagrina nodosa*, Parker & Jones.

"Sample No. 3 (Dredging, Shell Bank, off Ardnamurchan, 20 fms.), was a large bag (2335 c.c.) of fine and coarse clean brown shell debris which yielded 128 species, many being represented by relatively gigantic specimens, e. g., *Vaginulina legumen*, Linné sp., *Polymorphina gibba*, d'Orbigny, and *P. sororia*, Reuss (both highly fistulose), and *Pulvinulina repanda*, Fichtel & Moll sp. attaining sizes of 1–3 mm. The sample yielded also *Crithionina mamilla*, Goës, *Reophax findens*, Parker sp., and *R. moniliforme*, Siddall, *Lagena ornata*, Williamson, *L. spumosa*, Millett, and remarkable specimens of *L. marginata*, Walker & Boys sp., *Gypsina vesicularis*, Parker & Jones sp., and many other rare species.

"Sample No. 4 (Dredging, Loch Sunart, 20 fms.), is not yet completely worked out, but has already yielded 140 species, including *Frondicularia spathulata*, Brady, and *Bulimina subteres*, Brady, from a block of harsh grey mud of 1000 c.c. bulk. The dominant forms are *Nodosaria scalaris*, Batsch, and *Nonionina umbilicatula*, Montagu sp., with a very complete series of Buliminæ, showing every gradation from *B. elegans*, d'Orbigny, through *B. pupoides*, d'Orb., and *B. marginata*, d'Orb., to *B. aculeata*, d'Orb.

"So far as we have been able to clean the material, the shore-sands promise to give results not less rich than the dredgings we have already examined, and we hope, in the near future, to contribute to Prof. Herdman's series of 'Spolia Runiana' a paper on this very remarkable series of gatherings."

Mr. Heron-Allen has very kindly sent me a list of the 259 species of Foraminifera which he and Mr. Earland have found in the four samples which they have up to now examined. But I do not include the list here, as it is probable that the remaining 20 bags will add materially to the record which I hope they will publish in full when the work is completed.

II. Funiculina quadrangularis (*Pallas*).

At the end of the statement which I made last year in regard to the limited distribution of this magnificent Pennatulid, I ventured to add: "I do not doubt that other localities will yet be discovered on the West Coast of Scotland containing virgin forests of this largest and stateliest of the British Cœlenterata." In this year's work we have added four localities to those previously known, viz.: (1) Loch Sunart, near the mouth, opposite Tobermory, 22 fathoms; (2) Loch Nevis, to the east of Tarbet Bay, 30 to 40 fathoms; (3) Loch Hourn, off Piper Island, 20 fathoms, and also further up near the "narrows"; (4) Loch Shell, in Harris, 25 to 30 fathoms—in all cases from a muddy bottom. The original locality, near Oban, between the islands of

Kerrera and Lismore, in the Firth of Lorn, is, however, the spot where this giant "sea-pen" seems to live in greatest abundance and to attain to the largest size (62 inches is still my greatest recorded length of colony). It is pretty clear now that *Funiculina quadrangularis* is widely distributed in the more sheltered sea-lochs of Scotland, at depths of about 20 fathoms and upwards *, and always embedded in a bottom of stiff mud.

The abundance of *Funiculina* material we obtained in the Firth of Lorn this year, enabled us to keep some alive, under observation, in baths and basins on deck, and to record the colours in the living expanded condition and also the phenomena of its "phosphorescence." Professor Newstead photographed for me some colonies, living in a long tube of sea-water, where the polypes had expanded to a length of nearly an inch (see Pl. **19**. fig. 1).

In regard to the "phosphorescence" or luminosity, we were able to watch the colour and distribution of the light emitted both (1) when observed freshly dredged (a very few minutes after being taken from the sea) in an excellent make-shift dark-room—the lazarette of the yacht ; and also (2) some hours afterwards, lying in their basins of sea-water on the deck at midnight. In the two cases the phenomena were the same, and it was noticed that the distribution of the light is quite different from that in the better-known *Pennatula phosphorea*. In the latter form the light appears to be restricted to the polypes. I have not been able to excite any luminosity in the stem portion of the Pennatula colony, but illumination of the polypes is very general and beautiful—more general and more lasting than the luminosity of that part of the colony in *Funiculina*.

In *Funiculina quadrangularis*, however, while there are many distinct sparkles scattered over the polype-bearing part of the colony (corresponding, no doubt, to the individual polypes), the long, bare lower part of the stem, 9 inches to a foot in length, when gently stroked in the dark glows with a continuous sheet of light of (it seemed to me) a pale green † colour which flickers or pulsates like a lambent flame. The light on this bare part of the colony is certainly more intense than that of the polypes, and is, I think, the most brilliant "phosphorescence" I have seen in any marine animal.

During the cruise a letter was received from Professor Hickson asking me if I found the allied smaller sea-pen, *Virgularia mirabilis*, to determine, if possible, whether that form was phosphorescent and could sting. As both of the other British Pennatulids, *Funiculina* and *Pennatula*, had been exhibiting a brilliant display of light, I fully expected to find the *Virgularia* was also luminous ; and was therefore rather astonished, when we did dredge a couple of colonies of *V. mirabilis* in Loch Nevis, to notice that, although stimulated in various ways in the dark, not the slightest trace of

* Sir Wyville Thomson records having dredged it in abundance in the Sound of Raasay from a depth of 100 fathoms, on the 'Porcupine' Expedition.

† Wyville Thomson in 'Depths of the Sea' refers to the "lilac phosphorescence" of *Funiculina*.

light was visible ; while small *Funiculina* colonies, dredged at the same time and treated in the same way, were phosphorescing freely. I did not notice any stinging or numbing effect in handling any of the above-mentioned three species of Pennatulids.

The colour notes which I made from the living *Funiculina* are as follows :—The stem of the colony is pale yellow to ivory-white in tint, quite opaque in the centre and translucent along the edges. In an expanded polype, measuring about three-quarters of an inch in its free part, the lower half inch or so is translucent and of a greyish colour. The upper, or distal, quarter inch, where the stomodæum and the mesenterial filaments show through, varies from an opaque yellow to an orange-red—the stomodæum being the yellower part and the mesenterial filaments the redder. The expanded tentacles are of a delicate pinkish white, and the edge of the mouth is marked by a narrow line of opaque yellow. The blending of these colours, when seen at a little distance, gives the general orange-pink effect which is characteristic of the expanded polype fresh from the sea.

In a colony a little over three feet in length (say one metre) the largest polypes, when fully expanded, measured about $\frac{3}{8}$ of an inch in the length of their free part projecting above the stem (see Plate **19.** fig. 1). The spiral arrangement of the polypes upon the stem is very evident in the living colony.

This abundant fresh *Funiculina* material has enabled us to fill a gap in the knowledge of its minute structure. The Marshalls, in 1882, were unable to find in their Oban specimens any trace of the male gonads, and the male *Funiculina* has remained undescribed to the present day. Miss H. Muriel Duvall, B.Sc., a post-graduate worker in my laboratory, has been examining with me some of the fresh *Funiculina* material plunged living into 10 per cent. solution of formalin in sea-water, and we have been fortunate enough, after some searching, to find the missing male gonads. They were found first in a moderate-sized colony of a much paler colour (in formol solution) than the pinker ones in which we were finding the mature female gonads.

The male gonads of *Funiculina* are of much the same appearance and structure as those of *Pennatula*. They are globular masses (spermospheres) of rather smaller size than the mature ova, and consist of an external cellular capsule, a distinct structureless membrane (mesoglœa), and a central mass of small nucleated cells which evidently, as the gonads mature, increase greatly in number and become radially fusiform, and are then packed together in masses running inwards from the wall towards a central space. Out of seven colonies we have now examined, three were male and four female, the males being rather the smaller and so distinctly paler in colour that, after seeing the first one, Miss Duvall successfully predicted which of the remaining colonies would prove to be male.

III. Diazona violacea, *Savigny*.

I have this year been extraordinarily fortunate in obtaining abundance of material of this remarkable species. Previous to my record of last year, I believe only two specimens were known from Hebridean Seas—the one described by Forbes and Goodsir in 1851 as "*Syntethys hebridicus*" and the colony which I noted in 1891 * as having been dredged by the late Duke of Argyll, north of Mull, in 1885. Last year I found one good colony off Barra Head in the Outer Hebrides, and a few small fragments from the East Shiant Bank in the North Minch. This year I dredged over 30 colonies —most of them from a bank in the Inner Sound, north of the Croulin Islands †, at a depth of about 30 fathoms, but some off the West coast of Skye across the mouth of Loch Snizzort, outside the Ascrib Islands, from 30 to 40 fathoms.

At the Meeting of the British Association at Birmingham last September, I exhibited to the Section of Zoology two large museum jars, the one containing several bright violet colonies of *Diazona* preserved in alcohol, while the other had an equal number of colonies preserved in a solution of formol and still showing distinctly the green colour of the living animal. The contrast in appearance between the two jars was most marked, and was due merely to the method of preservation, all the colonies having been equally green when placed alive in their respective fluids. In the discussion, I was then asked the question—What will be the result if you now put one of the green formol-preserved specimens into alcohol? I am now able to answer that question as follows :—

On September 24th I washed one of the colonies from the green jar in running fresh water for a couple of hours, to remove the formol from the surface, and placed it in absolute alcohol at 5.40 P.M.

Up to 6.0 P.M. no change was visible.

September 25th, 9.30 A.M., the alcohol was tinged with green and the colony looked paler.

September 26th—the alcohol was much greener.

October 2nd—handed the green alcohol over to Dr. A. Holt for chemical examination, and transferred the colony, now of a pale green colour, nearly colourless in places, and of crystalline appearance on the surface, to a jar of new colourless alcohol.

October 3rd—the alcohol beginning to be green.

October 4th—fluid still greener ; colony seems colourless on surface.

November 4th—there has been no further change for some weeks. The

* Ann. & Mag. Nat. Hist. for August 1891 (ser. 8, vol. vi.), p. 165.

† This is probably the same spot from which Forbes and Goodsir, when on Mr. R. McAndrew's yacht in 1851, dredged the first-described specimen of "*Syntethys*."

fluid is distinctly yellow-green. The colony when taken out of the alcohol is now of a light yellowish-grey tint, but has very little colour. No violet has appeared in any part.

It seems, then, that the change from green to violet, as the result of preservation in alcohol, can only be effected in the case of the living, or at least unfixed, animal; and that the specimen which has been preserved in formol, although it will still give out a green colour when treated with alcohol, does not become violet.

A further new point I have now to state, in connection with the colour-changes of this Ascidian, is that even the living colony exposed in a vessel of sea-water to bright sunlight for a few days changes its colour to a notable degree, and may even develop a certain amount of violet or blue coloration on the surface of the colony. The abundance of material obtained off the Croulin Islands enabled me, after preserving some specimens in a tank of spirit (these became violet at once), and others in a jar of 10 per cent. formol (these remained green), to allow others to remain alive in basins of sea-water on deck under observation.

The first change noted was that the green Hebridean *Diazona* becomes distinctly greener during the first hour or so of exposure to sunlight. When brought up fresh from a depth of 20 or 30 fathoms the colony is of a delicate grey-green colour and has a gelatinous translucent appearance. But the green soon becomes more vivid and opaque, and the colony is then more solid in appearance. The green, after the lapse of some hours, then changes gradually from a yellow-green to a still more opaque and darker green, and then to a blue-green. After two or three days' exposure to light (the sea-water in the basins was frequently renewed during these observations) the colour of the colony round its margins, and especially in the upper parts of the test occupied by the ascidiozooids, became distinctly bluish, bluish violet, or slate-blue, usually very much of the tint of freshly spilt "Stephens's blue-black" ink—and in this condition it remained. Some of the colonies after a few days further captivity, were evidently dead or moribund; the others we preserved in the tank of spirit, and they are now all violet in colour like the rest.

Up to the last, however, the change in colour is only superficial, affecting at the most the outer quarter to half inch in thickness of the test. Similarly, the change to violet in the case of specimens preserved in alcohol, deep and opaque though the colour may seem, affects only the surface-layer of the test. Even now, after some months preservation in several changes of spirit, if a colony be cut open the centre is found to be of a vivid green colour; and it is interesting to notice that that green is now permanent, even when exposed to clean alcohol. Apparently the change to violet only takes place in the case of the fresh specimen taken from sea-water and placed in spirit.

As specimen after specimen of the living ascidian went through the same series of colour-changes before our eyes this summer, it is probable that we have seen all that can be determined from observation of the living animal, and that any further investigation of the pigmentation must be undertaken by the chemist in the laboratory.

Dr. Alfred Holt, of the Physical Chemistry department of the University of Liverpool, has kindly undertaken to investigate the pigment or pigments of these Hebridean colonies of *Diazona* from the chemical point of view. He reports to me as follows on his investigation so far :—

"Animal investigated was purple outside, but yellow-green inside. The purple and yellow-green portions were investigated separately.

"(1) *Purple part.*—Cut up into small fragments or ground with sand and then extracted in a Soxhlet with absolute alcohol, the colour gradually passed into solution. The solution thus obtained was bluish green in colour, quite distinct from the colour of the inner part of the animal or from the alcoholic solution obtained from the fresh animal on capture. This blue-green solution on evaporation at a low temperature (below 100° C.) gave a small residue which by transmitted light had no decided colour, but by reflected light was purple, identical in colour with that of the animal. The colour was soluble again in alcohol or zylene, solution taking a long time. The zylene extract had a more pronounced blue tint than that in alcohol.

"The addition of alkali to the blue-green solution changed the colour to a greenish yellow.

"(2) *Green part.*—The colouring matter of the inner green part was very easily soluble in alcohol to a green solution, the colour of which was, however, far more yellow than that of the purple part. On evaporation at low temperature this yellow-green solution yielded a green residue, not purple, and was again easily soluble in alcohol. The addition of alkali did not materially change its colour.

"The green parts of the animal did not go purple in alcohol. The fresh animal preserved in formaldehyde maintained its green colour, and this was readily and completely soluble in alcohol.

"Acid had no marked effect, nor acid nor alkaline hydrogen peroxide in dilute solution.

"From the absorption spectrum and general characters it would seem that the pigment in the purple portion is very similar to that obtained by Friedländer from *Murex brandaris*, and which was subsequently shown by him to be an indigo derivative. If this be so, then the yellow-green colour of the alcoholic solution from the inner (not purple) portion of the animal can scarcely be due to this pigment. Microscopic examination of this part shows numerous globules containing what looks like a yellow oil, and it is probably the solution of this oil that gives the yellow-green colour to the alcohol. The particular shade of tint may vary, depending on the

amount of the blue purple (indigo ?) dissolved in the yellow oil, and so producing a greenish shade. Attempts are at present being made to extract the colouring matter by Friedländer's method and so prove its chemical nature."

Dr. Holt proposes to publish a paper later on his chemical investigation of these pigment changes.

The fresh material has enabled me to make some further observations on the arrangement of the ascidiozooids as seen in the living and expanded colony. It is clear that, in some colonies at least, the ascidiozooids are not placed evenly over the whole of the upper surface, nor are they scattered irregularly, but are arranged in definite rows or groups with meandering branching paths of smooth depressed test between. So that, looking at the top of the expanded colony from above, one sees certain bare areas of test, as shown in Plate 19. fig. 2. In all probability this grouping of the ascidiozooids is the result of lines of budding in the growth of the young colony. In Alder and Hancock's 'British Tunicata'* the arrangement of the ascidiozooids is described as "forming a single, irregular, or very indistinctly concentric system"; but there is no reason to regard this as forming a single "system," and the arrangement is certainly not concentric.

In fig. 3, I show the arrangement of the "ocelli" or pigment spots in relation to the branchial and atrial siphons and also the lines of snow-white pigmentation on the thorax, as these structures are not represented correctly in Forbes and Goodsir's figures. There are six ocelli at the atrial aperture and none at the branchial, but a circle of white pigment spots surrounds the base of the branchial siphon, a short row of dots runs from this in the mediodorsal line to the nerve ganglion, a double line of white pigment bounds the endostyle along the ventral margin of the branchial sac, and two parallel white bands run along the dorsal edge of the thorax, terminating anteriorly in a single row of white dots facing that of the ganglion on the opposite side of the atrial siphon (see fig. 3). Each siphon terminates in six lobes.

IV. The Systematic Position of *Forbesella tessellata* (Forbes).

This West Coast species was first described by Forbes in 1848 † as *Cynthia tessellata*. Forbes's specimens were dredged by McAndrew in Mounts Bay, Cornwall, from 25 fathoms, and the species has since been found in deep water at several localities round the South and West coasts. In 1891, from the examination of some specimens dredged off the west of the Isle of Man, I drew attention to the fact that this species seemed to occupy an intermediate position between the subfamilies Cynthiinæ and Styelinæ, agreeing with the former in the compound tentacles and with the latter in having only four

* Edited by Hopkinson, Ray Soc., vol. ii. 1907, p. 159.

† British Mollusca, vol. i. p. 38.

folds on each side of the branchial sac. In my "Revised Classification of the Tunicata," read before this Society in February 1891 *, I therefore placed the species in a separate genus, *Forbesella* ; and in 1893 † I redescribed and figured it in more detail. In 1892 Lacaze-Duthiers and Delage ‡, from the examination of specimens found off the coast of Brittany, quite independently came to the same conclusions as my own, and had proposed to form for the reception of this species a new genus "*Forbesia*" ; but on receiving my paper of 1891 they accepted the generic name *Forbesella* there-in defined.

More recently Hartmeyer, in the new edition of Bronn's "Tier-Reichs," 1909, p. 1335, places both *Forbesella* and *Forbesia* as synonyms of his genus *Pyura*, the modern equivalent of *Cynthia*. His defence for so doing is that what seem the two most notable characteristics of *Forbesella tessellata*, namely, the tessellated or plate-like condition of the test and the small number of folds in the branchial sac, are both characters that are found in other species which he brings under his comprehensive genus *Pyura*. It may be remarked, however, that even on his own showing the combination of these two characters is not found in any other species ; but, apart from that, it is quite questionable whether species showing such a small number of folds in the branchial sac ought to be placed in *Pyura* (= *Cynthia*). In his discussion of the matter Hartmeyer states that two or possibly three species show five folds on each side, and that one (*Pyura stubenrauchi*, Meichaelsen) has on each side only four folds. The species that have five folds on each side I would regard as undoubtedly members of the genus *Pyura* or *Cynthia*, but the species with only four folds, if the existence of that character as a normal condition is established, I would unite with the species *tessellata* in the genus *Forbesella*. The species *Cynthia stubenrauchi* of Michaelsen § was described from a single preserved specimen brought home from the Straits of Magellan. In such a case it is of course quite possible that the single specimen examined was an abnormal individual, and I doubt whether on such evidence we are justified in making the proposed change in our classification.

I make a considerable distinction between the presence of eight folds and of ten. Four folds on each side is a well-marked character of the subfamily Styelinæ (according to some authors the family Styelidæ), while the Cynthias have a variable number of folds, from five on each side upwards. In discussing such matters of classification one must look at the problem from the standpoint of phylogeny. The ancestral Styelinæ and Cynthiinæ diverged presumably when their common ancestors had four folds on each side of the branchial sac, and thereafter the Styelas seem to have fixed the character of

* Journ. Linn. Soc., Zool. vol. xxiii. p. 558.

† Journ. Linn. Soc., Zool. vol. xxiv. p. 451.

‡ Mém. Acad. Sci. Inst. France, t. xlv. No. 1, p. 137.

§ Zoologica, Bd. xxxi. p. 102 : Stuttgart, 1900.

four folds in their line of descent, whereas the Cynthias acquired a greater number. In addition there is the further characteristic derived from the condition of the tentacles, which remained simple in Styelids and became compound in the Cynthiidæ. In my opinion, then, we are justified in considering that a species which presents us with only four folds on each side must be excluded from the genus *Cynthia* or *Pyura*; but as it has compound tentacles it must equally be excluded from the genus *Styela*. Therefore I would place both Forbes's *tessellata* and Michaelsen's *stubenrauchi*, if the latter has undoubtedly not more than eight folds, together in the genus *Forbesella*, occupying an intermediate position between *Styela* and *Cynthia*, and representing an early offshoot from the ancestral Cynthiids after they had attained compound tentacles, but before the number of folds in the branchial sac had increased beyond a total of eight.

I have now before me a series of specimens of *Forbesella tessellata*, obtained during the cruise of the 'Runa,' from five localities on the west of Scotland, viz. :—

(1) Loch Sunart, 20 fathoms.
(2) Off Island of Canna, 60 fathoms.
(3) South of Neist Point, Skye, 42 fathoms.
(4) Off the Croulin Islands, 30 fathoms.
(5) Inner Sound north of Croulins, 50 fathoms.

This series demonstrates clearly the very definite nature of the flat plates or scales into which the test is modified, and which are much more perfect and regular than the rough tubercles or surface elevations found in some species of *Cynthia*. I give (Pl. 19. fig. 4) a tracing with the "Edinger" drawing-apparatus to show the very definite polygonal shapes and arrangement of these plates from one of my Hebridean specimens.

The internal structure of these northern individuals agrees, so far as I have examined it, very closely with that of specimens from the Isle of Man. The branchial sac again, as in the former specimens, shows some variations; but in all cases the folds never exceed four on each side, which, taken along with the compound tentacles, in my opinion places this curious little form in an intermediate position between *Cynthia* and *Styela* and entitles it to rank as a distinct genus, *Forbesella*, in the subfamily Cynthiinæ.

V. Variation in *Ascidia*.

The large specimens of *Ascidia mentula*, Müll., and *Ascidia venosa*, Müll., which came up in the dredge on various occasions suggested to me that it might be useful to examine the individual variation in some of the internal organs which are usually described among the specific characters of these two well-marked species.

Ascidia mentula and *A. venosa* * are easily distinguished by their external appearance. Amongst more than a hundred specimens collected and preserved there was not a single doubtful case. Although individuals vary to some extent, especially in *A. mentula*, still every specimen can at a glance be referred to one or the other species.

I had removed a number of the freshly-dredged specimens of both species from their tests, thinking that this would ensure better preservation; but examination of the material now shows that this was a mistake, as these "skinned" specimens are so contracted and distorted as to be much less suitable for investigation than those specimens where the test was left as a support to the more delicate tissues within.

We † picked out ten well-preserved specimens of each species and made microscope preparations of the wall of the branchial sac, of the entire series of branchial tentacles, and of the dorsal tubercles, with the following results :—The specimens of *Ascidia mentula* ranged in length (antero-posterior) from 12 to 16 cm. The tentacles were found to vary in number from 39 to 103, and the number seems to bear no relation to the size of the body, since the individual with only 39 was actually larger than the one with 103 tentacles. The most usual number for the tentacles is from 60 to 90 ‡. The tentacles are always of more than one size §, and usually three distinct sizes or orders are present. The proportion of those of the first (largest) order to the rest varies from one-ninth to one-half—one-third ‖ being the proportion most frequently found. As *Ascidia mentula* usually lies attached with the left side downwards, it would not be surprising to find that some of the apparent irregularities in size and position of the tentacles bore some definite relation to the two sides of the body, but no such relation exists. In some specimens it is the right and in others it is the left side that has the largest or the greatest number of tentacles. One individual examined had 4 tentacles of the first order on the right side and 3 on the left, while another with 4 tentacles on the right side had no less than 11 on the left. There is a considerable range of individual variation in the spacing of the tentacles, which may be densely crowded (Pl. **19.** fig. 7) or sparsely scattered (fig. 5), or show intermediate gradations. Figures 5 and 6 show the

* We are not at the moment concerned with the question whether or not it is convenient to separate *venosa* in an independent genus *Ascidiella*.

† Miss H. M. Duvall, B.Sc., a post-graduate worker in my laboratory, has kindly assisted me in this investigation.

‡ In the L. M. B. C. Memoir on "Ascidia" I find that, as the result of a number of specimens examined, I then gave the number characteristic of the species as being from 70 to 100.

§ In Alder and Hancock's 'British Tunicata,' vol. i. (1905), under *Ascidia mentula*, we are told on p. 76 that the "tentacular filaments" are of "equal length," while on p. 79 they are said to "vary considerably in size." The latter is the more correct statement.

‖ This agrees with what is stated in the L. M. B. C. Memoir.

extremes found in one and the same individual: in these examples the tentacles are in the proportion of 4 to 9 in a given space. We are of opinion, however, that the unequal crowding of the tentacles in places is due in part to unequal contraction of the sphincter muscles. Consequently, individuals probably do not differ so much from one another as might be supposed, and authors in describing the condition of the tentacles would do well to take the state of contraction of the sphincters into consideration. The apparent crowding on the dorsal and ventral edges which is sometimes seen is mainly due to muscular contraction.

Calling the tentacles of the first, second, and third orders 1, 2, and 3, the normal scheme of arrangement in *Ascidia mentula* is :—1, 3, 2, 3, 1 (see fig. 8) ; but there is much individual variation: the third order of tentacles is especially variable, and in places where they are crowded those of the third order are liable to be squeezed out and the remaining tentacles then appear more equal in size.

The specimens of *Ascidia venosa* examined ranged from 7 to 11 cm., and the tentacles varied in number from 38 to 74—the most usual number being from 40 to 50. In this species also there seems to be no correlation between the number of tentacles and the size (probably =age) of the individual. The average proportion of the largest tentacles to the rest is one-half. Here, again, as in *A. mentula*, there is no correlation between the arrangement of the tentacles and the right and left sides of the body.

In making a comparison between *A. venosa* (fig. 9) and *A. mentula* (figs. 5 to 8), we find that the tentacles in the former are more slender, have a smaller range in number, and show less variation in size and arrangement and spacing, and any crowding noticed seems to be due to muscular contraction.

Turning now to the Dorsal Tubercle in the same specimens of these two species, we find that it is distinctly smaller in *A. venosa* than in *A. mentula*. The typical form in *A. mentula* is a horseshoe shape with the two free ends, or "horns," turned in the same direction, say to the right side, so that the right-hand horn turns outwards and the left inwards. The commoner variations are that both horns may turn to the left side, or both turn inwards, or one turn inwards and the other remain straight or nearly so. Out of the ten dorsal tubercles examined, six have at least one horn turned to the right.

In *Ascidia venosa* the typical form is a deep U-shape. Out of the ten specimens examined eight are simply U-shaped, and two have one horn turned inwards.

Finally, we examined the condition of the branchial sac in the same two series of individuals. In comparing branchial sacs it is desirable to examine pieces taken from corresponding parts of the wall ; and, in fact, the samples we have made use of were all cut out from the centre of the right-hand wall about the middle of its length.

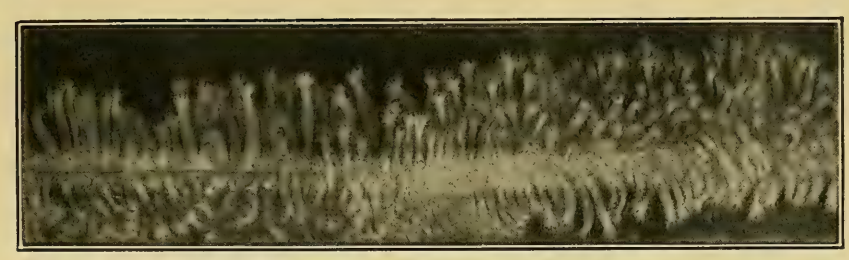
In *A. mentula* the usual characters of the branchial sac seem to be as follows :—There is well-marked "plication" of the wall, intermediate papillæ are always present on the internal bars halfway between the transverse vessels, the stigmata are wide and short and vary from 5 to 16 in a mesh—the usual numbers being from 9 to 12.

In *A. venosa* the plication of the wall is much less marked, there are no intermediate papillæ (except occasionally where a range of stigmata is in process of dividing into two—and in that case the papillæ are not really "intermediate" as they will eventually be at the angles of meshes), the stigmata are longer and narrower and more regular, and vary in number from 7 to 15 in a mesh, the usual numbers being from 8 to 12.

If we now attempt to draw some conclusions from these studies of the variation of the internal organs which are considered of most importance in defining the species, they must be to this effect :—*Ascidia mentula* and *A. venosa* can always be easily distinguished from one another by the external appearance either alive or when preserved. They may also be readily distinguished when stripped of the test. In the hundred or more specimens which we have just passed through our hands there has never been the least doubt as to which species each individual belonged to. Of the two, *A. mentula* is the more variable. Then, again, when examining the microscopic anatomy of the internal organs, such as the branchial sac, there is a general facies which is found to be characteristic of the organ in each of the species and which in most cases enables one to name the species correctly. But it is important to note that in these organs the range of individual variation in what are usually regarded as specific characters may, as we have seen, be very wide, and the extremes of the one species may reach to or even overlap those of the other. Consequently, it might be difficult in the case of a given preparation of an organ, say branchial sac or tentacles, placed under the microscope to determine the species with certainty, but even in that case if the other internal organs are available for examination, from the combination of characters there ought to be no difficulty in making a correct identification.

These two species which I have chosen out first for the purpose of such a comparison of their characteristics are very distinct from one another—so much so, in fact, that they are sometimes placed in separate but neighbouring genera, *Ascidia* and *Ascidiella* *. I am afraid, when one comes to deal in this manner with the variations in other more closely related so-called species of *Ascidia*, it will not prove such an easy matter to discriminate and define. There is no doubt that such investigations ought to be made whenever large series of individuals can be obtained, and I feel pretty sure that the work

* Separated off mainly on account of the relative positions of the nerve-ganglion and the dorsal tubercle.



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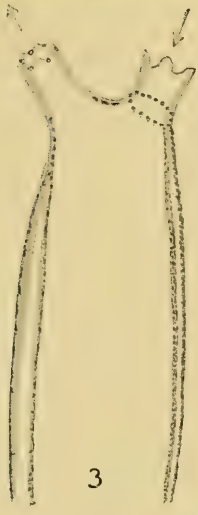

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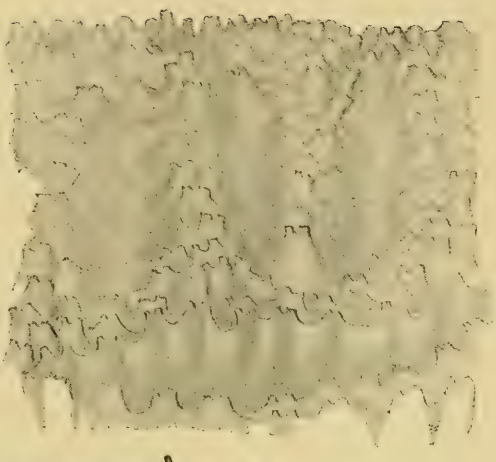

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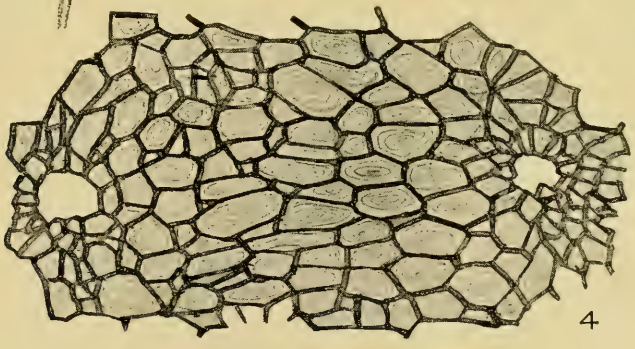

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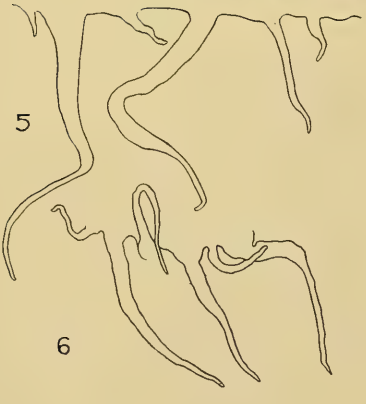

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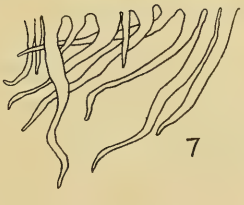

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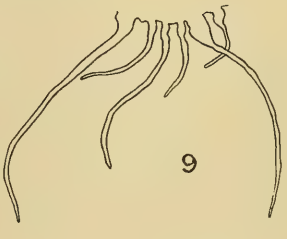

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W. A. H. del. Grout sc. & imp.

SPOLIA RUNIANA.

will result in a considerable number of the named and described British Ascidians being shown to have no existence as distinct species. That will probably be the fate of some of the supposed species described by Hancock, and by myself and others, from single specimens in some cases preserved in spirit and possibly distorted. These descriptions may have served a useful purpose at a certain stage in our knowledge of the group, but the names may eventually in the light of further study and comparison have to be removed from the list of valid species.

I had hoped to have included in the present study some further series of common forms of Ascidians which I had collected from the 'Runa' for the purpose; but other work has come in the way, and they must now be left over for some future occasion when I shall hope to publish the results in another part of "Spolia Runiana."

EXPLANATION OF PLATE 19.

Fig. 1. *Funiculina quadrangularis* (Pallas), alive and expanded in a cylinder of sea-water—about half natural size. From a photograph.

Fig. 2. *Diazona violacea*, Sav., alive and expanded to show the arrangement of the ascidiozooids; reduced a little.

Fig. 3. Anterior end of an ascidiozooid of *Diazona violacea* to show the arrangement of the lines of white pigment on the thorax. Enlarged.

Fig. 4. *Forbesella tessellata* (Forbes), upper surface of the test to show the plates. Enlarged.

Figs 5 to 8. *Ascidia mentula*, Müll., showing variation in tentacles.

Fig. 5. Sparsely scattered arrangement of tentacles.

Fig. 6. More crowded condition found in another part of the same individual.

Fig. 7. Densely crowded arrangement of tentacles.

Fig. 8. The typical arrangement of the tentacles in *A. mentula*.

Fig. 9. Tentacles of *Ascidia venosa*, Müll.—Figs. 5 to 9 all enlarged about 10 times.